Cardiac Catheterization and Angiography

MCG Health
Ambulatory Care
27th Edition

ACG: A-0001 (AC)
Link to Codes

Clinical Indications for Procedure

- Cardiac catheterization and angiography may be indicated for **1 or more** of the following:
  - Cardiac transplant patient, for surveillance of cardiac allograft vasculopathy and acute rejection following transplant(10)(11)(12) N
  - Congenital heart disease, known or suspected, as indicated by **1 or more** of the following(1)(14)(15)(16): N
    - Coronary anomaly, known or suspected(17)
    - Direct measurement of pressure gradients or oxygen saturations needed (eg, for intracardiac shunt, valvular heart disease)(18)
    - Invasive procedure planned, and preoperative or postoperative catheterization or angiographic imaging needed (eg, for pressure and gradient measurements)
    - Noninvasive imaging is nondiagnostic or discordant with physical examination findings.
    - Supravalvular aortic stenosis, known, and coronary imaging needed due to symptoms of coronary ischemia (eg, angina, dyspnea, syncope, arrhythmia)
  - Coronary artery disease, known or suspected, as indicated by **1 or more** of the following(2)(6)(19)(20)(21)(22): N
    - Angina at rest or crescendo angina (ie, unstable angina), and noninvasive stress imaging is unavailable, contraindicated, or nondiagnostic(12)
    - Angina recurrent within 9 months of percutaneous coronary intervention
    - Evidence of high risk based on noninvasive testing, as indicated by **1 or more** of the following(12)(19)(46)(47):
      - Cardiac CT angiography-defined disease, as indicated by **1 or more** of the following:
        - Left main coronary artery with 50% or greater stenosis
        - Obstructive coronary artery disease with CT-derived fractional flow reserve of 0.8 or less
        - Severe (70% or greater) stenosis in 3 main vessels
      - Cardiogenic shock, known or suspected, as indicated by **ALL** of the following(48)(49):
        - Signs and symptoms of circulatory shock, as indicated by **1 or more** of the following:
          - Altered mental status
          - Elevated serum lactate level (2.0 mmol/L (18 mg/dL) or more)
          - Hypotension
          - Metabolic acidosis (arterial or venous pH less than 7.35) not otherwise explained
          - Respiratory rate greater than 20 breaths per minute
          - Tachycardia
          - Urine output less than 0.5 mL/kg/hr
        - Signs and symptoms of heart failure (eg, dyspnea, orthopnea, pulmonary or peripheral edema, cyanosis)
      - Coronary artery calcium score at least 300 Agatston units, or at least 75th percentile for age, sex, and ethnicity(50)
      - Duke Treadmill Score less than or equal to -11[A]
      - Echocardiographic wall motion abnormality involving greater than 2 segments, developing at dobutamine dose of less than 10 mcg/kg per minute or at heart rate less than 120 beats per minute
      - Left ventricular ejection fraction 40% or less at rest
      - Perfusion imaging shows evidence of global ischemia or large territory of myocardium at risk.

- Stress electrocardiogram findings of ST-segment elevation, ventricular arrhythmia, or at least 2 mm of ST-segment depression(52)
- Stress-induced large perfusion defect or multiple moderate perfusion defects
- Stress-induced left ventricular dysfunction
- Transient ischemic dilation

- Following myocardial infarction and during risk-stratification phase, and **1 or more** of the following:
  - Clinically significant heart failure during hospital course
  - Ischemia at low level of exercise on noninvasive testing
  - Left ventricular ejection fraction 45% or less, and patient unable to undergo noninvasive testing
  - Treated with fibrinolytic therapy, and invasive treatment strategy planned(3)(52)
- Ischemia recurrent (by clinical or noninvasive testing) within 12 months of coronary artery bypass graft(53)
- Non-ST-elevation coronary syndrome, and invasive strategy determined(23)(47)(52)
- Occupation of patient directly involves safety of others (eg, bus driver, pilot, firefighter), and **1 or more** of the following(54)(55):
  - Abnormal results on noninvasive testing
  - Risk factors for coronary artery disease[B]
- Pericarditis (acute), suspected, when signs and symptoms, troponin levels, and pattern of ST elevation cannot definitively rule out acute infarction
- Prinzmetal (variant) angina, suspected(12)(38)
- Progressive abnormalities on noninvasive testing
- Resuscitation of patient from cardiac arrest or ventricular tachycardia(41)(57)(58)
- Risk stratification required (eg, prior to high-risk noncardiac surgery) in patient who cannot undergo noninvasive testing due to disability or illness
- Stent thrombosis, suspected, either abrupt closure or subacute, following percutaneous coronary intervention(23)(59)

- Coronary artery dissection, spontaneous, suspected(60)(61)(62)

- Heart failure, known or suspected, as indicated by **1 or more** of the following(59)(64)(65)(66):
  - Associated with angina or anginal equivalent
  - Constrictive pericarditis
  - Episodic heart failure with preserved ejection fraction on noninvasive testing
  - Left ventricular ejection fraction less than 45%, unexplained by noninvasive testing(67)
  - Post myocardial infarction, when left ventricular ejection fraction 35% or less
  - Postmyocardial infarction ventricular aneurysm
  - Preoperative planning needed before cardiac transplant or mechanical circulatory support
  - Restrictive cardiomyopathy
  - Reversible ischemia on stress echocardiogram or myocardial perfusion imaging, and revascularization (ie, coronary artery bypass graft, percutaneous coronary intervention) being considered
  - Wall motion abnormality involving more than 2 segments with low-dose dobutamine or at heart rate less than 120 beats per minute

- Hypertrophic cardiomyopathy, known or suspected, as indicated by **1 or more** of the following(68)(69):
  - Coronary artery disease suspected, as indicated by **ALL** of the following:
    - Chest discomfort in setting of intermediate to high likelihood of coronary artery disease
    - Identification of coronary artery disease will affect management.
  - Measurement of left ventricular outflow gradient needed due to equivocal or discordant results on noninvasive testing
  - Septal reduction therapy needed (eg, alcohol septal ablation, surgical myectomy)

- Kawasaki disease, known(70)(71)
- Preoperative or preprocedural planning needed before high-risk surgery for aneurysm repair without known coronary artery disease

- Pulmonary artery extrinsic compression of left main coronary artery, known or suspected, as indicated by **ALL** of the following(6):
  - Ischemic heart disease, as indicated by anginal symptoms or abnormal left ventricular function
  - Long-standing pulmonary hypertension(18)

- Pulmonary hypertension, known or suspected(18)(73)(74)(75)(76)

- Valvular heart disease, known or suspected, as indicated by **1 or more** of the following(79)(80):
  - Atrial myxoma, when transesophageal echocardiography is indeterminate
  - Mild to moderate valvular heart disease, as indicated by **1 or more** of the following:
    - Canadian Cardiovascular Society class II, III, or IV angina[C]
    - Ejection fraction 45% or less
    - Heart failure
    - Ischemia documented by noninvasive testing
  - Noninvasive test results are inconclusive, inconsistent, or discordant with patient symptoms.
  - Patient is symptomatic and echocardiographic findings are equivocal with regard to severity of valve disease.

- Preoperative, preprocedural, or intraprocedural planning needed for indicated valve surgery, transcatheter valve replacement or repair, or mitral balloon valvuloplasty, as indicated by **1 or more** of the following(12)(82):
    - Age or menopausal status, as indicated by **1 or more** of the following:
        - Male patient age 40 years or older
        - Postmenopausal female patient
    - Coronary artery disease, known or suspected (due to risk factors, symptoms, or noninvasive testing)[B]
    - Ejection fraction less than 55%
    - Percutaneous mitral valve repair, and need to evaluate concomitant coronary artery disease
    - Transcatheter aortic valve replacement, and need to evaluate concomitant coronary artery disease(83)
- Preoperative planning needed before Ross procedure to identify coronary orifices if not identified noninvasively
- Severe aortic or mitral regurgitation on echocardiography, as indicated by **1 or more** of the following[D]:
    - Aortic regurgitation diagnosed as severe on echocardiography, as indicated by **1 or more** of the following:
        - Doppler jet width 50% or greater of left ventricular outflow tract
        - Effective regurgitant orifice 0.3 cm^2 or greater
        - Holodiastolic aortic flow reversal
        - Left ventricular dilation
        - Left ventricular ejection fraction less than 55%
        - Regurgitant fraction 50% or greater
        - Regurgitant volume 60 mL per beat or greater
        - Vena contracta 0.6 cm or greater
    - Mitral regurgitation diagnosed as severe on echocardiography, as indicated by **1 or more** of the following(12)(80):
        - Effective regurgitant orifice 0.4 cm^2 or greater
        - Left ventricular dilation
        - Left ventricular ejection fraction 60% or less
        - Left ventricular end-systolic dimension 40 mm or greater
        - Regurgitant fraction 50% or greater
        - Regurgitant volume 60 mL or greater
        - Vena contracta 0.7 cm or greater
    - Physical examination findings discordant with echocardiographic or other noninvasive imaging findings
    - Pulmonary hypertension

☐ Repeat evaluation of specific area or structure with same imaging modality, and **ALL** of the following:

- Clinical need for repeat imaging, as indicated by **1 or more** of the following:
    - Change in clinical status (eg, worsening symptoms or new associated symptoms), and findings may impact treatment
    - Need for interval reassessment that may impact treatment plan
    - Need for re-imaging either prior to or after performance of invasive procedure
- Prior imaging results of specific area or structure with same imaging modality documented and available for comparison

Evidence Summary

Background

Cardiac catheterization and angiography is an invasive procedure that includes fluoroscopy after injection of contrast material via catheter into the great vessels, chambers, and coronary vessels of the heart, as well as saphenous vein grafts and arterial bypass grafts or other arterial conduits such as the mammary arteries. In addition to demonstrating areas of stenotic, regurgitant, or otherwise abnormal blood flow, coronary angiography with left and right heart catheterization or left ventriculography enables quantitative assessment of myocardial function, such as left ventricular ejection fraction, cardiac output, or degree of shunting.(1) **(EG 2)** It also enables quantitative assessment of coronary blood flow.(2) **(EG 2)** Invasive coronary angiography remains the gold standard for visualization and characterization of the coronary anatomy.(3)(4)(5) **(EG 2)** However, radiation exposure and nephrotoxicity from contrast material are significant factors that limit the duration and frequency of angiography.(6)(7)(8) **(EG 2)**

Criteria

For cardiac transplant patients, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** It has been noted that a major cause of death in post-transplant patients is coronary artery vasculopathy, and cardiac catheterization with intravascular ultrasound is useful for surveillance of cardiac allograft vasculopathy and silent obstructive coronary artery disease.(10)(13) **(EG 2)** Right heart catheterization is useful for hemodynamic assessment in post-transplant patients and to facilitate endomyocardial biopsy to provide histologic monitoring for transplant rejection.(13) **(EG 2)**

For congenital heart disease, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** The availability of noninvasive imaging has made angiography

less important for diagnosis.(1)(14) **(EG 2)** However, it is indicated in both children and adults before surgery when repair may involve the coronary arteries or because of chest pain. It may also be indicated for complex congenital heart disease, particularly when intracardiac shunting is present.(14) **(EG 2)** A specialty society guideline notes that cardiac catheterization and coronary angiography may be indicated for accurate measurement of congenital pulmonary or aortic stenosis gradients and to delineate anatomy, as well as for accurate assessment of pulmonary artery pressure and pulmonary vascular resistance. Pulmonary angiography and right ventriculography are recommended for pulmonary stenosis in particular. For patients with repaired tetralogy of Fallot, coronary artery compression testing (via cardiac catheterization) is recommended prior to transcatheter valve replacement or right ventricle-to-pulmonary artery conduit stenting. For transposition of the great arteries, the authors note that it is reasonable to perform anatomic evaluation of coronary artery patency in asymptomatic adults following an arterial switch procedure; coronary angiography is recommended if this patency cannot be established noninvasively. Cardiac catheterization can also be useful in the assessment of coarctation and recoarctation of the aorta, of sinus venosus defects and coronary anomalies, and of vascular rings.(15) **(EG 2)**

For coronary artery disease, evidence demonstrates at least moderate certainty of at least moderate net benefit. **(RG A1)** Coronary angiography is indicated for evaluation of stable angina when symptoms cannot be medically controlled, are disabling, and when interventional treatment has been proposed as the next form of therapy.(23)(24)(25) **(EG 2)** Specialty society guidelines recommend coronary angiography for risk assessment in patients with stable ischemic heart disease in whom clinical characteristics and noninvasive testing results suggest a high likelihood of severe disease when such patients are amenable to and are candidates for coronary revascularization.(19)(24)(25)(26) **(EG 2)** Coronary angiography by cardiac catheterization allows for the use of fractional flow reserve, which is a useful tool for determining the hemodynamic significance of coronary lesions, particularly those of intermediate severity.(3) **(EG 2)** A review article notes that, compared to angiography alone, the use of fractional flow reserve to guide revascularization has been shown to reduce morbidity in patients with intermediate-grade stenoses.(27) **(EG 2)** Other review articles state that the use of fractional flow reserve during invasive coronary angiography is accepted as the gold standard for functional assessment of fixed coronary lesions.(28)(29) **(EG 2)** A specialty society guideline notes that the use of cardiac catheterization and coronary angiography provides an invasive approach to risk stratification in patients with non-ST-elevation acute coronary syndrome without recurrent ischemia in the first 24 hours, and can identify the 10% to 20% of patients with no significant coronary stenoses and the approximately 20% of patients with 3-vessel coronary artery disease with left ventricular dysfunction or with left main coronary artery disease.(23) **(EG 2)** A randomized trial of 496 patients with non-ST-elevation acute coronary syndrome compared acute coronary angiography (within 2 hours of diagnosis) with subacute coronary angiography (within 72 hours of diagnosis) and found, at 1-year follow-up, no difference between the groups in all-cause mortality, recurrent myocardial infarction, or admission for ischemia or heart failure.(30) **(EG 1)** A randomized trial of 2147 patients with non-ST-elevation acute coronary syndrome compared early coronary angiography (within 12 hours of diagnosis) with standard care coronary angiography (within 48 to 72 hours of diagnosis) and found, at a median follow-up of 4.3 years, no difference between the groups in all-cause mortality, nonfatal recurrent myocardial infarction, or hospitalization for refractory ischemia or heart failure.(31) **(EG 1)** In a post hoc analysis of a randomized trial of 4071 patients with non-ST-elevation myocardial infarction who underwent coronary angiography, earlier performance of coronary angiography (within 12 hours after admission) was associated with a lower risk of ischemic outcomes at 180 days.(32) **(EG 1)** Coronary angiography is indicated when noninvasive imaging suggests the possibility of left main coronary artery stenosis or severe multivessel disease, or to guide percutaneous interventions.(6)(19) **(EG 2)** Several risk scoring systems and clinical prediction tools have been created to help differentiate patients who are likely to have significant obstructive disease on coronary angiography from those who are not, as well as to help determine the optimal revascularization strategy and clinical outcomes.(33)(34)(35) **(EG 2)** Specialty society guidelines state that calculation of the Society of Thoracic Surgeons and SYNTAX (Synergy between Percutaneous Coronary Intervention with TAXUS and Cardiac Surgery) scores is reasonable in patients who have unprotected left main coronary artery lesions and complex coronary artery disease.(3) **(EG 2)** A cohort study involving 903 patients previously randomized to percutaneous coronary intervention found that the residual SYNTAX score was a powerful indicator of 5-year mortality, with a residual SYNTAX score (as determined by coronary angiography) of greater than 8 being associated with an all-cause mortality of 35.3% at 5 years.(36) **(EG 2)** An observational study of 37,674 patients undergoing elective coronary angiography found that the presence of nonobstructive coronary artery disease, as compared with no apparent coronary artery disease, was predictive of 1-year risk of myocardial infarction and all-cause mortality.(37) **(EG 2)** It has been noted that coronary angiography with provocative testing is the gold standard for diagnosis of coronary spasm with variant angina.(6)(38)(39) **(EG 2)** A prospective study of 921 patients concluded that the intracoronary acetylcholine provocation test is a safe technique for assessment of coronary vasomotor function.(40) **(EG 2)** A systematic review and meta-analysis of 32 nonrandomized studies concluded that coronary angiography should be considered irrespective of electrocardiographic findings in patients resuscitated from out-of-hospital cardiac arrest that does not have an obvious noncardiac etiology.(41) **(EG 2)** A multicenter randomized trial of 552 patients resuscitated after out-of-hospital cardiac arrest (all of whom had an initial shockable rhythm and no evidence of ST-elevation myocardial infarction after return of spontaneous circulation) compared immediate angiography with angiography delayed until neurologic recovery and found, at 90-day follow-up, no difference in overall survival between the groups.(42) **(EG 1)** Several large retrospective studies have found that early coronary angiography in patients with out-of-hospital arrest is associated with improved survival and functional recovery.(43)(44)(45) **(EG 2)**

For coronary artery dissection occurring spontaneously, evidence demonstrates at least moderate certainty of at least moderate net benefit. **(RG A1)** Spontaneous coronary artery dissection has been found in 0.2% to 4% of patients with acute coronary syndrome undergoing invasive coronary angiography.(63) **(EG 2)** A retrospective cohort study of 87 patients found that spontaneous coronary artery dissection affected a predominantly young female population and was confirmed by coronary angiography in 100% of patients.(60) **(EG 2)** A review article notes that invasive coronary angiography remains the first-line diagnostic tool for the evaluation of spontaneous coronary artery dissection, primarily because the majority of cases present clinically as acute coronary syndromes.(61) **(EG 2)** Appropriate-use criteria endorsed by multiple specialty societies note that diagnostic coronary angiography is indicated for the evaluation of suspected coronary artery dissection.(59) **(EG 2)**

For heart failure or cardiomyopathy, evidence demonstrates at least moderate certainty of at least moderate net benefit. **(RG A1)** Specialty society guidelines state that cardiac catheterization and coronary angiography are appropriate for the evaluation of ischemia in heart failure patients.(59)(64)(65) **(EG 2)** A specialty society guideline indicates that right heart catheterization with a pulmonary artery catheter is recommended in patients with severe heart failure who are being evaluated for heart transplant or mechanical circulatory support.(66) **(EG 2)**

For hypertrophic cardiomyopathy, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** A specialty society guideline states that cardiac catheterization and coronary angiography are useful for the evaluation of left ventricular outflow gradient (eg, with isoproterenol infusion), for the evaluation of suspected coronary artery disease, and for the performance of alcohol septal ablation and surgical myectomy in patients with obstructive hypertrophic cardiomyopathy.(69) **(EG 2)**

For Kawasaki disease, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** Kawasaki disease is associated with coronary artery aneurysms, for which coronary angiography is useful for definitive imaging of the coronary arteries and great vessels.(70)(71) **(EG 2)** A specialty society guideline states that coronary angiography should be performed in patients with Kawasaki disease who are known to have medium or giant aneurysms during the convalescent phase or later in order to monitor for development or progression of localized stenoses, because myocardial ischemia due to Kawasaki disease cannot be fully detected by other imaging modalities and may manifest as sudden cardiac death.(70) **(EG 2)** A specialty society consensus statement notes that, although invasive coronary angiography is rarely performed during the acute phase of Kawasaki disease, angiography can be useful for later identification and periodic surveillance of coronary artery aneurysms, particularly when signs of ischemia are present.(71) **(EG 2)**

For preoperative or preprocedural planning before high-risk surgery for aneurysm repair, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** A retrospective review of 205 patients referred for cardiac catheterization prior to elective ascending aortic aneurysm surgery showed that there were no adverse events related to the procedure; coronary artery disease was found in 19% of patients. The authors recommended that coronary angiography be part of the routine preoperative evaluation for this patient population.(72) **(EG 2)**

For pulmonary artery extrinsic compression of the left main coronary artery, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** Coronary angiography is noted to be a highly accurate imaging procedure to delineate arterial anatomy, including extrinsic compression.(6) **(EG 2)**

For pulmonary hypertension, evidence demonstrates at least moderate certainty of at least moderate net benefit. **(RG A1)** Review articles note that right heart catheterization is useful for the measurement of pulmonary artery pressures and right heart hemodynamics, and for the evaluation of potential response to treatment (ie, vasoreactivity testing).(73)(74)(76) **(EG 2)** A systematic comparative effectiveness review notes that right heart catheterization is the gold standard for diagnosing pulmonary arterial hypertension.(75) **(EG 2)** A specialty society guideline states that right heart catheterization with a pulmonary artery catheter should be considered in patients with heart failure with probable pulmonary hypertension diagnosed by echocardiography before correction of underlying valvular or structural heart disease.(66) **(EG 2)** A scientific statement endorsed by multiple specialty societies recommends right heart catheterization for diagnostic confirmation of pulmonary hypertension in renal and liver transplant candidates if preoperative transthoracic echocardiography shows evidence of elevated pulmonary arterial pressures.(77) **(EG 2)** In pediatric patients with bronchopulmonary dysplasia, an expert consensus document states that cardiac catheterization may be indicated to confirm the echocardiographic diagnosis of pulmonary hypertension, determine disease severity, evaluate the potential contributions of shunt lesions (eg, atrial or ventricular septal defects, patent ductus arteriosus), and define the need for combination drug therapy for the treatment of pulmonary hypertension.(78) **(EG 2)**

For valvular heart disease, evidence demonstrates a net benefit, but of less than moderate certainty, and may consist of a consensus opinion of experts, case studies, and common standard care. **(RG A2)** Coronary angiography is indicated prior to valve surgery for evaluation of the coronary arteries in patients with suspected or known coronary artery disease or decreased left ventricular systolic function, in all male patients age 40 years or older, and in all postmenopausal female patients. It is also indicated when findings on noninvasive testing are internally inconsistent or when they are discordant with clinical findings. A specialty society guideline states that coronary angiography should be performed as part of the evaluation of patients with chronic severe secondary mitral regurgitation. Cardiac catheterization may be indicated to assess hemodynamics, coronary artery anatomy, and severity of valve disease in the setting of equivocal echocardiographic evidence regarding the severity of valvular heart disease.(80) **(EG 2)**

Inconclusive or Non-Supportive Evidence

For routine preoperative screening, evidence demonstrates a lack of net benefit; additional research is recommended. **(RG C1)** A specialty society guideline states that no benefit has been found for the use of coronary angiography for routine preoperative screening. (9) **(EG 2)**

References

1. Woodard PK, et al. Known or Suspected Congenital Heart Disease in the Adult. ACR Appropriateness Criteria [Internet] American College of Radiology (ACR). 2016 Accessed at: https://www.acr.org. [created 1996; accessed 2022 Aug 26] [Context Link 1, 2, 3]

2. Neumann FJ, et al. 2018 ESC/EACTS guidelines on myocardial revascularization. European Heart Journal 2019;40(2):87-165. DOI: 10.1093/eurheartj/ehy394. (Reaffirmed 2022 Jul) [Context Link 1, 2] View abstract...

3. Lawton JS, et al. 2021 ACC/AHA/SCAI guideline for coronary artery revascularization: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation 2022;145(3):e18-e114. DOI: 10.1161/CIR.0000000000001038. (Reaffirmed 2022 Jan) [Context Link 1, 2, 3, 4] View abstract...

4. King SB. Is coronary arteriography a diagnostic test? JACC. Cardiovascular Interventions 2013;6(1):97-98. DOI: 10.1016/j.jcin.2012.12.003. [Context Link 1] View abstract...

5. Jiangping S, et al. Assessment of coronary artery stenosis by coronary angiography: a head-to-head comparison with pathological coronary artery anatomy. Circulation. Cardiovascular Interventions 2013;6(3):262-268. DOI: 10.1161/CIRCINTERVENTIONS.112.000205. [Context Link 1] View abstract...

6. Dangas GD, Mehran R. Coronary angiography and intravascular imaging. In: Libby P, Bonow RO, Mann DL, Tomaselli GF, Bhatt DL, Solomon SD, editors. Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine. 12th ed. Elsevier; 2022:363-384. [Context Link 1, 2, 3, 4, 5, 6]

7. Azzalini L, Candilio L, McCullough PA, Colombo A. Current risk of contrast-induced acute kidney injury after coronary angiography and intervention: a reappraisal of the literature. Canadian Journal of Cardiology 2017;33(10):1225-1228. DOI: 10.1016/j.cjca.2017.07.482. [Context Link 1] View abstract...

8. Werner GS, et al. A prospective study on the incidence of contrast-associated acute kidney injury after recanalization of chronic total coronary occlusions with contemporary interventional techniques. International Journal of Cardiology 2021;337:38-43. DOI: 10.1016/j.ijcard.2021.05.030. [Context Link 1] View abstract...

9. Fleisher LA, et al. 2014 ACC/AHA Guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: A report of the American College of Cardiology/American Heart Association Task Force on practice guidelines. Circulation 2014;130(24):e278-e333. DOI: 10.1161/CIR.0000000000000106. (Reaffirmed 2022 Jul) [Context Link 1] View abstract...

10. Torres HJ, et al. Prevalence of cardiac allograft vasculopathy assessed with coronary angiography versus coronary vascular ultrasound and virtual histology. Transplantation Proceedings 2011;43(6):2318-2321. DOI: 10.1016/j.transproceed.2011.06.002. [Context Link 1, 2] View abstract...

11. Chih S, Chong AY, Mielniczuk LM, Bhatt DL, Beanlands RS. Allograft vasculopathy: the Achilles' heel of heart transplantation. Journal of the American College of Cardiology 2016;68(1):80-91. DOI: 10.1016/j.jacc.2016.04.033. [Context Link 1] View abstract...

12. Knuuti J, et al. 2019 ESC Guidelines for the diagnosis and management of chronic coronary syndromes. European Heart Journal 2020;41(3):407-477. DOI: 10.1093/eurheartj/ehz425. (Reaffirmed 2022 Jan) [Context Link 1, 2, 3, 4, 5, 6] View abstract...

13. Jessup M, et al. 2017 ACC/AHA/HFSA/ISHLT/ACP advanced training statement on advanced heart failure and transplant cardiology (revision of the ACCF/AHA/ACP/HFSA/ISHLT 2010 clinical competence statement on management of patients with advanced heart failure and cardiac transplant): a report of the ACC Competency Management Committee. Circulation: Heart Failure 2017;10(6):e000021. DOI: 10.1161/HHF.0000000000000021. (Reaffirmed 2022 Jul) [Context Link 1, 2] View abstract...

14. Valente AM, Dorfman AL, Babu-Narayan SV, Krieger EV. Congenital heart disease in the adolescent and adult. In: Libby P, Bonow RO, Mann DL, Tomaselli GF, Bhatt DL, Solomon SD, editors. Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine. 12th ed. Elsevier; 2022:1541-1586. [Context Link 1, 2, 3]

15. Stout KK, et al. 2018 AHA/ACC guideline for the management of adults with congenital heart disease: a report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. Circulation 2019;139(14):e698-e800. DOI: 10.1161/CIR.0000000000000603. (Reaffirmed 2022 Jul) [Context Link 1, 2] View abstract...

16. Ohuchi H, et al. JCS 2022 guideline on management and re-interventional therapy in patients with congenital heart disease long-term after initial repair. Circulation Journal 2022;86(10):1591-1690. DOI: 10.1253/circj.CJ-22-0134. [Context Link 1] View abstract...

17. Dolgner S, Hickey E, Molossi S. Coronary artery anomalies. Heart 2022;108(13):1063-1070. DOI: 10.1136/heartjnl-2018-313927. [Context Link 1] View abstract...

18. Maron BA. Pulmonary hypertension. In: Libby P, Bonow RO, Mann DL, Tomaselli GF, Bhatt DL, Solomon SD, editors. Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine. 12th ed. Elsevier; 2022:1656-1677. [Context Link 1, 2, 3]

19. Fihn SD, et al. 2012 ACCF/AHA/ACP/AATS/PCNA/SCAI/STS guideline for the diagnosis and management of patients with stable ischemic heart disease: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines, and the American College of Physicians, American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. Circulation 2012;126(25):e354-e471. DOI: 10.1161/CIR.0b013e318277d6a0. (Reaffirmed 2022 Jun) [Context Link 1, 2, 3, 4] View abstract...

20. Mancini GB, et al. Canadian Cardiovascular Society guidelines for the diagnosis and management of stable ischemic heart disease. Canadian Journal of Cardiology 2014;30(8):837-849. DOI: 10.1016/j.cjca.2014.05.013. (Reaffirmed 2022 Aug) [Context Link 1] View abstract...

21. Bergmark BA, Mathenge N, Merlini PA, Lawrence-Wright MB, Giugliano RP. Acute coronary syndromes. Lancet 2022;399(10332):1347-1358. DOI: 10.1016/S0140-6736(21)02391-6. [Context Link 1] View abstract...

22. Expert Panel on Cardiac Imaging, et al. ACR Appropriateness Criteria® chronic chest pain-high probability of coronary artery disease: 2021 update. Journal of the American College of Radiology 2022;19(5S):S1-S18. DOI: 10.1016/j.jacr.2022.02.021. [Context Link 1] View abstract...

23. Amsterdam EA, et al. AHA/ACC guideline for the management of patients with non-ST-elevation acute coronary syndromes: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation 2014;130(25):e344-e426. DOI: 10.1161/CIR.0000000000000134. (Reaffirmed 2022 Jul) [Context Link 1, 2, 3, 4] View abstract...

24. Wolk MJ, et al. ACCF/AHA/ASE/ASNC/HFSA/HRS/SCAI/SCCT/SCMR/STS 2013 multimodality appropriate use criteria for the detection and risk assessment of stable ischemic heart disease: a report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for

Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. Journal of the American College of Cardiology 2014;63(4):380-406. DOI: 10.1016/j.jacc.2013.11.009. (Reaffirmed 2022 Jun) [Context Link 1, 2] View abstract...

25. Fihn SD, et al. 2014 ACC/AHA/AATS/PCNA/SCAI/STS focused update of the guideline for the diagnosis and management of patients with stable ischemic heart disease: a report of the American College of Cardiology/American Heart association task force on practice guidelines, and the American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. Circulation 2014;130(19):1749-1767. DOI: 10.1161/CIR.0000000000000095. (Reaffirmed 2022 Jul) [Context Link 1, 2] View abstract...
26. Qaseem A, et al. Diagnosis of stable ischemic heart disease: summary of a clinical practice guideline from the American College of Physicians/American College of Cardiology Foundation/American Heart Association/American Association for Thoracic Surgery/Preventive Cardiovascular Nurses Association/Society of Thoracic Surgeons. Annals of Internal Medicine 2012;157(10):729-734. DOI: 10.7326/0003-4819-157-10-201211200-00010. [Context Link 1] View abstract...
27. Parikh V, Agnihotri K, Kadavath S, Patel NJ, Abbott JD. Clinical application of fractional flow reserve-guided percutaneous coronary intervention for stable coronary artery disease. Current Cardiology Reports 2016;18(4):32. DOI: 10.1007/s11886-016-0711-3. [Context Link 1] View abstract...
28. Tarantini G, Migliore F, Cademartiri F, Fraccaro C, Iliceto S. Left anterior descending artery myocardial bridging: a clinical approach. Journal of the American College of Cardiology 2016;68(25):2887-2899. DOI: 10.1016/j.jacc.2016.09.973. [Context Link 1] View abstract...
29. Okutucu S, Cilingiroglu M, Feldman MD. Physiologic assessment of coronary stenosis: current status and future directions. Current Cardiology Reports 2021;23(7):88. DOI: 10.1007/s11886-021-01521-3. [Context Link 1] View abstract...
30. Rasmussen MB, et al. Comparison of acute versus subacute coronary angiography in patients with NON-ST-elevation myocardial infarction (from the NONSTEMI trial). American Journal of Cardiology 2019;124(6):825-832. DOI: 10.1016/j.amjcard.2019.06.007. [Context Link 1] View abstract...
31. Kofoed KF, et al. Early versus standard care invasive examination and treatment of patients with non-ST-segment elevation acute coronary syndrome. Circulation 2018;138(24):2741-2750. DOI: 10.1161/CIRCULATIONAHA.118.037152. [Context Link 1] View abstract...
32. Deharo P, et al. Timing of angiography and outcomes in high-risk patients with non-ST-segment-elevation myocardial infarction managed invasively: insights from the TAO trial (treatment of acute coronary syndrome with otamixaban). Circulation 2017;136(20):1895-1907. DOI: 10.1161/CIRCULATIONAHA.117.029779. [Context Link 1] View abstract...
33. Brener SJ, Prasad AJ, Abdula R, Sacchi TJ. Relationship between the angiographically derived SYNTAX score and outcomes in high-risk patients undergoing percutaneous coronary intervention. Journal of Invasive Cardiology 2011;23(2):66-69. [Context Link 1] View abstract...
34. Palmerini T, et al. Comparison of clinical and angiographic prognostic risk scores in patients with acute coronary syndromes: Analysis from the Acute Catheterization and Urgent Intervention Triage StrategY (ACUITY) trial. American Heart Journal 2012;163(3):383-391.e1-e5. DOI: 10.1016/j.ahj.2011.11.010. [Context Link 1] View abstract...
35. Farooq V, et al. The CABG SYNTAX Score - an angiographic tool to grade the complexity of coronary disease following coronary artery bypass graft surgery: from the SYNTAX Left Main Angiographic (SYNTAX-LE MANS) substudy. EuroIntervention 2013;8(11):1277-1285. DOI: 10.4244/EIJV8I11A196. [Context Link 1] View abstract...
36. Farooq V, et al. Quantification of incomplete revascularization and its association with five-year mortality in the synergy between percutaneous coronary intervention with taxus and cardiac surgery (SYNTAX) trial validation of the residual SYNTAX score. Circulation 2013;128(2):141-151. DOI: 10.1161/CIRCULATIONAHA.113.001803. [Context Link 1] View abstract...
37. Maddox TM, et al. Nonobstructive coronary artery disease and risk of myocardial infarction. Journal of the American Medical Association 2014;312(17):1754-1763. DOI: 10.1001/jama.2014.14681. [Context Link 1] View abstract...
38. Kinlay S. Coronary artery spasm as a cause of angina. Circulation 2014;129(17):1717-1719. DOI: 10.1161/CIRCULATIONAHA.114.009219. [Context Link 1, 2] View abstract...
39. Zaya M, Mehta PK, Merz CN. Provocative testing for coronary reactivity and spasm. Journal of the American College of Cardiology 2014;63(2):103-109. DOI: 10.1016/j.jacc.2013.10.038. [Context Link 1] View abstract...
40. Ong P, et al. Clinical usefulness, angiographic characteristics, and safety evaluation of intracoronary acetylcholine provocation testing among 921 consecutive white patients with unobstructed coronary arteries. Circulation 2014;129(17):1723-1730. DOI: 10.1161/CIRCULATIONAHA.113.004096. [Context Link 1] View abstract...
41. Larsen JM, Ravkilde J. Acute coronary angiography in patients resuscitated from out-of-hospital cardiac arrest--a systematic review and meta-analysis. Resuscitation 2012;83(12):1427-1433. DOI: 10.1016/j.resuscitation.2012.08.337. [Context Link 1, 2] View abstract...
42. Lemkes JS, et al. Coronary angiography after cardiac arrest without ST-segment elevation. New England Journal of Medicine 2019;380(15):1397-1407. DOI: 10.1056/NEJMoa1816897. [Context Link 1] View abstract...
43. Waldo SW, et al. Comparison of clinical characteristics and outcomes of cardiac arrest survivors having versus not having coronary angiography. American Journal of Cardiology 2013;111(9):1253-1258. DOI: 10.1016/j.amjcard.2013.01.267. [Context Link 1] View abstract...
44. Zanuttini D, et al. Impact of emergency coronary angiography on in-hospital outcome of unconscious survivors after out-of-hospital cardiac arrest. American Journal of Cardiology 2012;110(12):1723-1728. DOI: 10.1016/j.amjcard.2012.08.006. [Context Link 1] View abstract...
45. Callaway CW, et al. Early coronary angiography and induced hypothermia are associated with survival and functional recovery after out-of-hospital cardiac arrest. Resuscitation 2014;85(5):657-663. DOI: 10.1016/j.resuscitation.2013.12.028. [Context Link 1] View abstract...
46. Gulati M, et al. 2021 AHA/ACC/ASE/CHEST/SAEM/SCCT/SCMR guideline for the evaluation and diagnosis of chest pain: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation 2021;144(22):e368-e454. DOI: 10.1161/CIR.0000000000001029. (Reaffirmed 2022 Aug) [Context Link 1] View abstract...
47. Kontos MC, et al. 2022 ACC expert consensus decision pathway on the evaluation and disposition of acute chest pain in the emergency department: a report of the American College of Cardiology Solution Set Oversight Committee. Journal of the American College of Cardiology 2022;80(20):1925-1960. DOI: 10.1016/j.jacc.2022.08.750. (Reaffirmed 2022 Oct) [Context Link 1, 2] View abstract...

48. Puskarich MA, Jones AE. Shock. In: Walls RM, editor. Rosen's Emergency Medicine. 10th ed. Philadelphia, PA 19103-2899: Elsevier; 2023:34-41.e1. [Context Link 1]

49. Naidu SS, et al. SCAI SHOCK stage classification expert consensus update: a review and incorporation of validation studies: this statement was endorsed by the American College of Cardiology (ACC), American College of Emergency Physicians (ACEP), American Heart Association (AHA), European Society of Cardiology (ESC) Association for Acute Cardiovascular Care (ACVC), International Society for Heart and Lung Transplantation (ISHLT), Society of Critical Care Medicine (SCCM), and Society of Thoracic Surgeons (STS) in December 2021. Journal of the American College of Cardiology 2022;Online. DOI: 10.1016/j.jacc.2022.01.018. [Context Link 1] View abstract...

50. Goff DC, et al. 2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Journal of the American College of Cardiology 2014;63(25 Pt B):2935-2959. DOI: 10.1016/j.jacc.2013.11.005. (Reaffirmed 2022 Jun) [Context Link 1] View abstract...

51. Balady GJ, Ades PA. Exercise physiology and exercise electrocardiographic testing. In: Libby P, Bonow RO, Mann DL, Tomaselli GF, Bhatt DL, Solomon SD, editors. Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine. 12th ed. Elsevier; 2022:175-195. [Context Link 1, 2]

52. Bhatt DL, Lopes RD, Harrington RA. Diagnosis and treatment of acute coronary syndromes: a review. Journal of the American Medical Association 2022;327(7):662-675. DOI: 10.1001/jama.2022.0358. [Context Link 1, 2, 3] View abstract...

53. Hattler B, et al. Incidence and prognostic impact of incomplete revascularization documented by coronary angiography 1 year after coronary artery bypass grafting. American Journal of Cardiology 2020;131:7-11. DOI: 10.1016/j.amjcard.2020.06.047. [Context Link 1] View abstract...

54. Sutton NR, et al. Coronary artery disease evaluation and management considerations for high risk occupations: commercial vehicle drivers and pilots. Circulation. Cardiovascular Interventions 2021;14(6):Online. DOI: 10.1161/CIRCINTERVENTIONS.120.009950. [Context Link 1] View abstract...

55. Gray G, et al. The challenge of asymptomatic coronary artery disease in aircrew; detecting plaque before the accident. Heart 2019;105(Suppl 1):s17-s24. DOI: 10.1136/heartjnl-2018-313053. [Context Link 1] View abstract...

56. Hajar R. Risk factors for coronary artery disease: historical perspectives. Heart Views 2017 Jul-Sep;18(3):109-114. DOI: 10.4103/HEARTVIEWS.HEARTVIEWS_106_17. [Context Link 1] View abstract...

57. Panchal AR, et al. Part 3: Adult basic and advanced life support: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation 2020;142(16_suppl_2):S366-S468. DOI: 10.1161/CIR.0000000000000916. [Context Link 1] View abstract...

58. Yannopoulos D, et al. The evolving role of the cardiac catheterization laboratory in the management of patients with out-of-hospital cardiac arrest: a scientific statement from the American Heart Association. Circulation 2019;139(12):e530-e552. DOI: 10.1161/CIR.0000000000000630. [Context Link 1] View abstract...

59. Patel MR, et al. ACCF/SCAI/AATS/AHA/ASE/ASNC/HFSA/HRS/SCCM/SCCT/SCMR/STS 2012 appropriate use criteria for diagnostic catheterization: American College of Cardiology Foundation Appropriate Use Criteria Task Force Society for Cardiovascular Angiography and Interventions American Association for Thoracic Surgery American Heart Association, American Society of Echocardiography American Society of Nuclear Cardiology Heart Failure Society of America Heart Rhythm Society, Society of Critical Care Medicine Society of Cardiovascular Computed Tomography Society for Cardiovascular Magnetic Resonance Society of Thoracic Surgeons. Catheterization and Cardiovascular Interventions 2012;80(3):E50-E81. DOI: 10.1002/ccd.24467. (Reaffirmed 2022 Jun) [Context Link 1, 2, 3, 4] View abstract...

60. Tweet MS, et al. Clinical features, management, and prognosis of spontaneous coronary artery dissection. Circulation 2012;126(5):579-588. DOI: 10.1161/CIRCULATIONAHA.112.105718. [Context Link 1, 2] View abstract...

61. Bastante T, et al. Current management of spontaneous coronary artery dissection. Expert Review of Cardiovascular Therapy 2017;15(8):619-628. DOI: 10.1080/14779072.2017.1357467. [Context Link 1, 2] View abstract...

62. Adlam D, et al. Spontaneous coronary artery dissection: pitfalls of angiographic diagnosis and an approach to ambiguous cases. JACC. Cardiovascular Interventions 2021;14(16):1743-1756. DOI: 10.1016/j.jcin.2021.06.027. [Context Link 1] View abstract...

63. Havakuk O, Goland S, Mehra A, Elkayam U. Pregnancy and the risk of spontaneous coronary artery dissection: an analysis of 120 contemporary cases. Circulation. Cardiovascular Interventions 2017;10(3):e004941. DOI: 10.1161/CIRCINTERVENTIONS.117.004941. [Context Link 1] View abstract...

64. Heidenreich PA, et al. 2022 AHA/ACC/HFSA guideline for the management of heart failure: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation 2022;145(18):e895-e1032. DOI: 10.1161/CIR.0000000000001063. (Reaffirmed 2022 Jun) [Context Link 1, 2] View abstract...

65. McKelvie RS, et al. The 2012 Canadian Cardiovascular Society heart failure management guidelines update: focus on acute and chronic heart failure. Canadian Journal of Cardiology 2013;29(2):168-181. DOI: 10.1016/j.cjca.2012.10.007. (Reaffirmed 2022 Jun) [Context Link 1, 2] View abstract...

66. McDonagh TA, et al. 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. European Heart Journal 2021;42(36):3599-3726. DOI: 10.1093/eurheartj/ehab368. (Reaffirmed 2022 Aug) [Context Link 1, 2, 3] View abstract...

67. Doherty JU, et al. ACC/AATS/AHA/ASE/ASNC/HRS/SCAI/SCCT/SCMR/STS 2019 appropriate use criteria for multimodality imaging in the assessment of cardiac structure and function in nonvalvular heart disease: A report of the American College of Cardiology Appropriate Use Criteria Task Force, American Association for Thoracic Surgery, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and the Society of Thoracic Surgeons. Journal of Thoracic and Cardiovascular Surgery 2019;157(4):e153-e182. DOI: 10.1016/j.jtcvs.2018.12.061. (Reaffirmed 2022 Jul) [Context Link 1] View abstract...

68. Elliott PM, et al. 2014 ESC Guidelines on diagnosis and management of hypertrophic cardiomyopathy: The Task Force for the Diagnosis and Management of Hypertrophic Cardiomyopathy of the European Society of Cardiology (ESC). European Heart Journal 2014;35(39):2733-2779. DOI: 10.1093/eurheartj/ehu284. (Reaffirmed 2022 Jul) [Context Link 1] View abstract...

69. Ommen SR, et al. 2020 AHA/ACC guideline for the diagnosis and treatment of patients with hypertrophic cardiomyopathy: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation 2020;142(25):e558-e631. DOI: 10.1161/CIR.0000000000000937. (Reaffirmed 2022 Aug) [Context Link 1, 2] View abstract...

70. JCS Joint Working Group. Guidelines for diagnosis and management of cardiovascular sequelae in Kawasaki disease (JCS 2013). Digest version. Circulation Journal 2014;78(10):2521-2562. [Context Link 1, 2, 3] View abstract...

71. McCrindle BW, et al. Diagnosis, treatment, and long-term management of Kawasaki disease: a scientific statement for health professionals from the American Heart Association. Circulation 2017;135(17):e927-e999. DOI: 10.1161/CIR.0000000000000484. (Reaffirmed 2022 Jul) [Context Link 1, 2, 3] View abstract...

72. Gertz ZM, Levitt SA, Epps KC, Bavaria JE, Moser GW, Kolansky DM. Cardiac catheterization in patients with ascending aortic aneurysms: safety, success, and prevalence of coronary artery disease. Journal of Invasive Cardiology 2014;26(6):241-244. [Context Link 1] View abstract...

73. Kiely DG, Elliot CA, Sabroe I, Condliffe R. Pulmonary hypertension: diagnosis and management. British Medical Journal 2013;346:f2028. [Context Link 1, 2] View abstract...

74. Mandel J, Poch D. Pulmonary hypertension. Annals of Internal Medicine 2013;158(9):ITC5-1. DOI: 10.7326/0003-4819-158-9-201305070-01005. [Context Link 1, 2] View abstract...

75. McCrory DC, et al. Pulmonary Arterial Hypertension: Screening, Management, and Treatment. Comparative Effectiveness Review #117 AHRQ Publication No. 13-EHC087-EF [Internet] Agency for Healthcare Research and Quality (AHRQ). 2013 Apr Accessed at: https://www.effectivehealthcare.ahrq.gov/. [accessed 2022 Apr 04] [Context Link 1, 2] View abstract...

76. Hassoun PM. Pulmonary arterial hypertension. New England Journal of Medicine 2021;385(25):2361-2376. DOI: 10.1056/NEJMra2000348. [Context Link 1, 2] View abstract...

77. Lentine KL, et al. Cardiac disease evaluation and management among kidney and liver transplantation candidates: a scientific statement from the American Heart Association and the American College of Cardiology Foundation: endorsed by the American Society of Transplant Surgeons, American Society of Transplantation, and National Kidney Foundation. Circulation 2012;126(5):617-663. DOI: 10.1161/CIR.0b013e31823eb07a. [Context Link 1] View abstract...

78. Krishnan U, et al. Evaluation and management of pulmonary hypertension in children with bronchopulmonary dysplasia. Journal of Pediatrics 2017;188:24-31 e1. DOI: 10.1016/j.jpeds.2017.05.029. [Context Link 1] View abstract...

79. Kern MJ, Seto AH, Herrmann J. Invasive hemodynamic diagnosis of cardiac disease. In: Libby P, Bonow RO, Mann DL, Tomaselli GF, Bhatt DL, Solomon SD, editors. Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine. 12th ed. Elsevier; 2022:385-409. [Context Link 1]

80. Otto CM, et al. 2020 ACC/AHA guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation 2020;143(5):e35-371. DOI: 10.1161/CIR.0000000000000923. (Reaffirmed 2022 Aug) [Context Link 1, 2, 3, 4, 5] View abstract...

81. Fang JC, O'Gara PT. History and physical examination: an evidence-based approach. In: Libby P, Bonow RO, Mann DL, Tomaselli GF, Bhatt DL, Solomon SD, editors. Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine. 12th ed. Elsevier; 2022:123-140. [Context Link 1]

82. Doherty JU, Kort S, Mehran R, Schoenhagen P, Soman P. ACC/AATS/AHA/ASE/ASNC/HRS/SCAI/SCCT/SCMR/STS 2017 appropriate use criteria for multimodality imaging in valvular heart disease: a report of the American College of Cardiology Appropriate Use Criteria Task Force, American Association for Thoracic Surgery, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Thoracic Surgeons. Journal of the American College of Cardiology 2017;70(13):1647-1672. DOI: 10.1016/j.jacc.2017.07.732. (Reaffirmed 2022 Jul) [Context Link 1] View abstract...

83. Prabhakar M, Liu S, Bagai A, Yanagawa B, Verma S, Cheema AN. Assessment and management of coronary artery disease in patients undergoing transcatheter aortic valve replacement. Current Opinion in Cardiology 2020;35(5):540-547. DOI: 10.1097/HCO.0000000000000768. [Context Link 1] View abstract...

84. Ribeiro HB, et al. Cardiovascular magnetic resonance to evaluate aortic regurgitation after transcatheter aortic valve replacement. Journal of the American College of Cardiology 2016;68(6):577-585. DOI: 10.1016/j.jacc.2016.05.059. [Context Link 1] View abstract...

85. Bonow RO, Leon MB, Doshi D, Moat N. Management strategies and future challenges for aortic valve disease. Lancet 2016;387(10025):1312-1323. DOI: 10.1016/S0140-6736(16)00586-9. [Context Link 1] View abstract...

Footnotes

[A] The Duke Treadmill Score incorporates exercise duration, the magnitude of ST-segment deviation, and exercise-induced angina; it identifies patients with a high probability of severe coronary artery disease (triple vessel or left main coronary artery disease) at angiography and with a higher mortality risk.(51) A low-risk score is +5 or greater, a moderate-risk score is between +4 and -10, and a high-risk score is -11 or less.(51) [A in Context Link 1]

[B] Risk factors for coronary artery disease include diabetes mellitus, hypertension, hyperlipidemia, tobacco use, family history of premature coronary artery disease, age, obesity, sedentary lifestyle, and chronic kidney disease.(56) [B in Context Link 1, 2]

[C] Canadian Cardiovascular Society class I angina occurs only with strenuous, rapid, or prolonged exertion; class II angina occurs with rapid walking or climbing stairs or a hill, after meals, in the cold or wind, or with emotional stress; class III angina occurs while walking 1 to 2 level blocks; with class IV angina, a patient is unable to carry on any physical activity without discomfort, and angina symptoms may be present at rest.(81) [C in Context Link 1]

[D] The severity of valvular regurgitation is determined and reported by specific imaging parameters that vary according to the imaging modality and are evaluated in combination with physical examination findings. These imaging parameters include the visual appearance and anatomic location of the regurgitant jet, Doppler measurements on echocardiography, and measurements of regurgitant volume on all imaging modalities.(80)(84)(85) A specialty society guideline recommends correlating physical examination findings with data from a comprehensive transthoracic echocardiogram when classifying the severity of valve lesions for the purposes of evaluating patients for a possible intervention.(80) [D in Context Link 1]

Definitions

Altered mental status

- Altered mental status (ie, different from baseline), as indicated by **1 or more** of the following(1)(2)(3)(4):
  - Confusional state (eg, disorientation, difficulty following commands, deficit in attention)
  - Lethargy (awake or arousable, but with drowsiness; reduced awareness of self and environment)
  - Obtundation (ie, arousable only with strong stimuli, lessened interest in environment, slowed responses to stimulation)
  - Stupor (may be arousable but patient does not return to normal baseline level of awareness)
  - Coma (not arousable)

References

1. Maher PJ. Confusion. In: Walls RM, editor. Rosen's Emergency Medicine. 10th ed. Philadelphia, PA 19103-2899: Elsevier; 2023:126-131.e1.
2. Lei C, Smith C. Depressed consciousness and coma. In: Walls RM, editor. Rosen's Emergency Medicine. 10th ed. Philadelphia, PA 19103-2899: Elsevier; 2023:117-125.e1.
3. Abraham G, Maher PJ. Delirium and dementia. In: Walls RM, editor. Rosen's Emergency Medicine. 10th ed. Philadelphia, PA 19103-2899: Elsevier; 2023:1269-1280.e2.
4. MacNeill EC, Vashist S. Approach to syncope and altered mental status. Pediatric Clinics of North America 2013;60(5):1083-1106. DOI: 10.1016/j.pcl.2013.06.013.

Hypotension

- Hypotension, as indicated by **ALL** of the following(1)(2)(3)(4):
  - Not patient baseline (eg, healthy adult with low SBP) or intentional therapeutic goal (eg, low SBP as treatment goal in heart failure)
  - Low blood pressure, as indicated by **1 or more** of the following:
    - SBP less than 90 mm Hg in adult or child 10 years or older[A]
    - Mean arterial pressure[A][B] less than 70 mm Hg in adult or child 10 years or older
    - Decrease in baseline mean arterial pressure of 25% or more,[A][B] with significant signs or symptoms due to lower blood pressure (eg, near syncope, syncope, chest pain)
    - SBP less than sum of 70 mm Hg plus twice patient's age in years in child 1 to 9 years of age[A]
    - SBP less than 70 mm Hg in infant 1 to 11 months of age[A]

References

1. Jones D, Di Francesco L. Hypotension. In: McKean SC, Ross JJ, Dressler DD, Scheurer DB, editors. Principles and Practice of Hospital Medicine. 2nd ed. New York, NY: McGraw-Hill Education; 2017:657-64.
2. Massaro AF. Approach to the patient with shock. In: Loscalzo J, Fauci A, Kasper D, Hauser S, Longo D, Jameson JL, editors. Harrison's Principles of Internal Medicine. 21st ed. McGraw Hill Education; 2022:2235-2241.
3. Horeczko T. Pediatric cardiac disorders. In: Walls RM, editor. Rosen's Emergency Medicine. 10th ed. Philadelphia, PA 19103-2899: Elsevier; 2023:2109-2131.e1.
4. Singh S, Holmes JF. Pediatric trauma. In: Walls RM, editor. Rosen's Emergency Medicine. 10th ed. Philadelphia, PA 19103-2899: Elsevier; 2023:2052-2066.e3.

Footnotes

A. Criteria based upon clinician acquired numeric values (eg, vital signs, oxygen saturation) should be used if they are accurate reflections of the patient's condition. Transitory findings (eg, abnormal only upon initial emergency department intake or only one time out of multiple readings) that rapidly improve with no or minimal treatment usually do not reflect disease severity or risk for deterioration. This does not imply that an initial or one-time reading cannot ever be applicable. The goal is to separate erroneous or incidental findings from those that truly represent the patient's clinical picture.

B. The mean arterial pressure takes into account both systolic and diastolic blood pressure readings and is calculated as Mean Arterial Pressure (MAP) = 1/3 SBP + 2/3 DBP. A calculator is available at https://www.mdcalc.com/mean-arterial-pressure-map.

Tachycardia

- Tachycardia,[A] as indicated by **1 or more** of the following(1)(2):
  - Heart rate greater than 100 beats per minute in adult or child age 6 years or older[A]
  - Heart rate greater than 115 beats per minute in child 3 to 5 years of age[A]
  - Heart rate greater than 125 beats per minute in child 1 or 2 years of age[A]
  - Heart rate greater than 130 beats per minute in infant 6 to 11 months of age[A]
  - Heart rate greater than 150 beats per minute in infant 3 to 5 months of age[A]
  - Heart rate greater than 160 beats per minute in infant 1 or 2 months of age[A]

References

1. Southmayd GL. Tachycardia. In: McKean SC, Ross JJ, Dressler DD, Scheurer DB, editors. Principles and Practice of Hospital Medicine. 2nd ed. New York, NY: McGraw-Hill Education; 2017:729-739.
2. Pediatric parameters and equipment. In: Kleinman K, McDaniel L, Molloy M, editors. The Harriet Lane Handbook: A Manual for Pediatric House Officers. 22nd ed. 202: Elsevier; 2021:frontpiece tables.

Footnotes

A. Criteria based upon clinician acquired numeric values (eg, vital signs, oxygen saturation) should be used if they are accurate reflections of the patient's condition. Transitory findings (eg, abnormal only upon initial emergency department intake or only one time out of multiple readings) that rapidly improve with no or minimal treatment usually do not reflect disease severity or risk for deterioration. This does not imply that an initial or one-time reading cannot ever be applicable. The goal is to separate erroneous or incidental findings from those that truly represent the patient's clinical picture.

Codes

CPT®: 0523T, 92978, 92979, 93451, 93452, 93453, 93454, 93455, 93456, 93457, 93458, 93459, 93460, 93461, 93462, 93505, 93563, 93564, 93565, 93566, 93567, 93568, 93569, 93571, 93572, 93573, 93574, 93575 [Hide]

HCPCS: C7516, C7517, C7518, C7519, C7520, C7521, C7522, C7523, C7524, C7525, C7526, C7527, C7528, C7529, C7552, C7553 [Hide]

Last Update: 9/21/2023 4:42:48 AM
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